SESSION 1

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Risks and benefits of biological and chemical plant protection strategies – food safety aspects

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INTRODUCTION

Food safety is an important part of public health linking health to agriculture and other food production sectors. Developments in food production and control have contributed to food safety systems in most developed countries perceived by many to be efficient in the prevention of disease and other problems related to food production. This perception has come under serious attack in recent years.

Whereas human health issues related to food have not been the focus of attention in most parts of the world up through the seventies and eighties, this picture has changed dramatically over the most recent decade. Some credit the heightened attention to food safety issues to a number of public scares related to food that seems to have shaken the confidence of consumers in our food safety efforts, at least in some parts of the world. While the influence of media-focus on scares should not be underestimated, several other developments in this area are likely to have had an even more important influence in the new public and political attention to this area.

This lecture will attempt a discussion of these factors as well as their influence on the assessment, evaluation and acceptance of different crop protection strategies. In focusing on the use of crop protection strategies and their relation to health, health effects will not be seen in isolation. The bigger picture of production of foods with the use of pesticides or from genetically modified (GM) plants therefore includes not only an assessment of direct health effects of such plants, but also consideration of how such production potentially could influence agricultural efficiency in developing countries, and thereby health and development. Likewise the bigger picture of production of foods through the use of pesticides includes not only the safety of certain levels of residues in the food, but also the questions of misuse or accidents related to pesticides, or even the question of broader effects of non-use of this type of plant protection.

FOOD SCARES AND REAL RISKS – PERCEPTION AND COMMUNICATION

The food scares that we have experienced over the last decade do not reflect the real picture of foodborne risk. This is clear in the microbiological area where outbreaks for some diseases regularly hit the press, whereas facts related to sporadic disease cases, which constitute the clear majority of the disease burden, almost never reach the press.

It is also clear in the chemical area, where the generally good efforts in relation to safety and risk assessment over more than forty years have still not resulted in efficient communication of the difference between the mere presence of a hazard and the level of human health risk. Notably we can – and do – have hazards in food which causes no human health risk, obvious examples would include threshold chemicals in concentrations below the acceptable intake or

bacteria, such as staphylococci, in concentrations below which toxin formation can cause health effects. Such chemicals or bacteria may represent hazards but at the given concentrations human health is maintained and they do not represent a human health risk.

A number of the problems in this area stem from poor risk communication. However, the issues related to changes in public perception and public involvement in decision-making goes deeper than simply communication failure.

International work related to safety and risk assessment of chemicals used in the production of food started forty years ago in JECFA (Joint FAO/WHO Expert Committee on food additives) and later JMPR (Joint FAO/WHO Expert Meeting on Pesticide Residues). In this period the standing of authorities and the view of science was dramatically different from the present-day situation. In many cases the authoritative statement of a scientist would be taken at face value, and assessments from government regulators would be accepted, basically as objective statements of fact.

This authoritative recognition did not only run through the food arena, in other areas, doctors judgements were accepted intuitively whereas statements based in contemporary science was almost never questioned. So whereas the food scares coupled with poor communication have undoubtedly had a significant influence in present-day doubts, it is also a reflection of a more general change in society's way of dealing with science, predictive assessments, uncertainty and control systems. Failure to understand such changes will result in repetition of past mistakes in this area.

One way of trying to incorporate new thinking is the new framework of risk analysis. Within this framework the importance of the basic preconditions behind the scientific assessment and following risk management and their interaction with risk perception as well as the crucial importance of (two-way) risk communication throughout all steps in this process. After a short description of relevant health considerations of pesticide use this presentation will attempt a description of this new framework and its implications for future improvements related to the performance of risk assessment and management within the sea of risk communication (see Figure 1).

PESTICIDE USE AND PESTICIDE RESIDUES

Pesticides are extensively used world-wide. In the EU 800 pesticides are currently registered (2001). The use of pesticides to control pests for agricultural and non-agriculture purposes can lead to the contamination of soils, surface and groundwater and air. As a result, pesticides residues and/or their metabolites can be found in food and drinking water.

Despite international efforts to promote sustainable use of pesticides in agriculture, and an actual reduction in use in several countries, since 1995 there has not been a significant overall reduction in pesticide use in the WHO European Region. Around two-thirds of all pesticide applications world wide are in Europe (Forastieri, 2000). Information about the presence of pesticides residues in foods is very limited. Monitoring programs have only recently been started in some countries. The European Union (EU) and Norway collected common data on pesticide residue levels in fruit and vegetables in 1996, extending the survey to fruit, vegetables and cereals in 1997 (European Commission, 1999). In the 1997 survey nearly 40%

of samples contained residues, with Maximum Residue Levels (MRLs) exceeded in one in twelve of the positive cases, and multiple residues found in one in six of the positive cases. The extent of drinking water contamination by pesticides in Europe is largely unknown. It has been estimated that in the EU the established drinking water standard of 0.5 µg/litre of total pesticides is exceeded in 65% of the groundwater of all agricultural land (European Commission, 1998).

It should be noted that MRLs are not always directly related to human health effects. A more direct relation to such effects can be achieved through the FAO/WHO Acceptable Daily Intake (ADI) system which relates to health effects by estimating the actual amount ingested by the human body (see also Chapter on Acute Toxicity).

While the effects of pesticide residues in food and water in many parts of the world is a very topical issue, it should not be forgotten that the major disease burden related to the broader issue of pesticide use comes from the high number of poisoning cases.

PESTICIDE POISONING

Estimations of single and short-term exposures, including intentional and unintentional poisoning, are presented in Table 1. The most recent estimates present astounding figures of 3,000,000 cases and 200,000 deaths (WHO, 1990), notably the bulk of these deaths were attributed to suicides. These estimations were based on studies in several developing countries and represents a situation where such compounds are easily available in many households and may become the "method of choice" for individuals with suicidal tendencies. In general, these figures include pesticide formulators, mixers and applicators as well as suicides, but they also include mass poisonings that are attributed to residues in food. Because most of these occur in developing countries which lack adequate reporting systems, these estimates are in some areas likely to be under-estimates. Measurements of acetylcholine esterase levels in farm workers in developing countries suggest that the occupational poisoning estimates may be low. It is estimated that long-term low-level exposures lead to about 735,000 cases of chronic defects and 37,000 cases of cancer annually. These may be related to occupational exposure, but may also be due to dietary exposure (WHO, 1990).

Table 1. Developments in the estimation of pesticide poisoning

1972:	500,000 accidental cases; 1% mortality rate, (could be higher in countries with poor treatment potential) (WHO, 1973)
1985:	1,000,000 cases of unintentional poisonings; case fatality rate 0.5- 2.0 % (WHO, 1985)
1990:	2,000,000 cases of intentional poisoning (suicide); 200,000 deaths* 1,000,000 cases of unintentional poisoning; 20,000 deaths (WHO, 1990)

* extrapolation from hospital data

An analysis of all reported pesticide poisonings in the United States showed that 57% of all cases involved children under the age of 6 years (Klein-Schwartz & Smith, 1997). Occupationally exposed workers such as pesticide applicators and farmers (and their families) are also at high risk. Pesticide exposure during pregnancy is associated with an increased risk of spontaneous abortion (Nurminen, 1995), fetal death (Bell *et al.*, 2001) and early childhood cancers such as acute lymphocytic leukemia (Infante-Rivard *et al.*, 1999).

PESTICIDES AND HEALTH EFFECTS

Health effects that have been associated with pesticides are: cancer and damage to reproductive, endocrine, immune or respiratory systems (Tirado, 2002). The human exposure to pesticides can be through ingestion, dermal absorption and inhalation. The ingestion vehicles can be: food, breast milk, drinking water (and soil). In addition humans, including children can be exposed to pesticides at the workplace or in households, schools, swimming areas etc.

Agricultural exposure to pesticides increases the risk of non-Hodgkins lymphoma (Hardell & Eriksson, 1999). Pesticides may also have cumulative (see later), neurotoxic effects contributing to diseases such as Parkinson's among people who are genetically susceptible (Hubble *et al.*, 1998).

Differences in pesticide exposure between children (including foetuses and infants) and adults exist, primarily due to differences in diets, but also differences in the toxicity between children and adults have been found (US NRC, 1993). Organochloride pesticide residues have been found in women's breast milk in levels which may raise concerns about the nursing infant (Schutz *et al.*, 1998). Multiple residues present in baby foods represent an additional concern especially for pesticides that share a common mechanism of toxicity. In a group of the baby foods most commonly sold in the United States, many contain multiple pesticides (Wiles & Davies, 1995), and most (90%) of American children are exposed to combinations of different organophosphate insecticides in food (Wiles *et al.*, 1998).

While a number of potential health effects of chemical substances have been recognized and investigated for many years some new considerations have surfaced more recently. The 1997 Geneva Joint FAO/WHO Consultation on Food Consumption and Exposure Assessment of Chemicals recognised the importance of issues such as cumulative additive effects of pesticides with common toxicity. The same Consultation considered the issue of acute toxicity and suggested new methodology for performing acute dietary exposure assessment (WHO, 1997). In the following these two new areas of assessment and potential future regulation will be briefly described. In addition, a new toxicological endpoint related to alteration of hormonal systems (endocrine disruption) will be briefly mentioned.

Acute toxicity

The traditional regulatory threshold of levels of intake of a chemical that will result in no appreciable effect is the acceptable daily intake (ADI). The definition of an ADI represents an average consideration allowing occasional exposure to levels above the ADI. Certain pesticides might however present an acute hazard, so that such excesses may be of toxicological concern.

Residue levels in certain individual commodities have a much higher variability than composite sampling results suggests. This and the use of traditional exposure assessment methodology for acute risks have sometimes had the net result of reducing exposure estimates, resulting in a situation where a residue at or near the MRL could be legally traded, but may still pose an unacceptable acute risk to the consumer. This suggests that the assessments procedures may be under-estimating risk for populations under certain conditions.

In addition, attempts to extrapolate the procedures used for chronic hazards to the risk assessment paradigm for acute hazards have encountered a number of difficulties both with regard to the hazard characterization and exposure assessment. For example, the use of safety factors (or uncertainty factors) will need to be reconsidered for acute hazards in terms of the severity of adverse effects, i.e. mild, reversible headaches in comparison to birth defects. On the exposure side, the assessment is targeted towards the high consumer who might be exposed to a high percentile residue. It should also be mentioned that the acute RfD is considered a 'bright line' in terms of public health and should not be exceeded. This has some important risk management implications, especially when violative residues are detected.

It has therefore been suggested that the ADI may not be the appropriate toxicological estimate of the amount of a substance that can be ingested without appreciable health risk during excursions of exposure that exceed the ADI. In such cases an acute Reference Dose (RfD) should be established to set an upper limit on such short-term excursions. The acute RfD is thus an estimate of the amount of a substance in food or drinking water that can be ingested over a short period of time without appreciable health risk. It is usually expressed in milligram per kilogram of body weight and refers to one meal or one day (WHO, 1997). For compounds that are toxic to key systems or functions the end-point for establishing an acute RfD can be easy to define, while this could be more difficult for compounds that have mild and/or questionable effects, and to complicate matters the acute RfD end-point might differ from that used to set the ADI.

Guidelines for assessing acute dietary risks, including guidelines on establishing acute RfD, are being developed in a number of regulatory jurisdictions, but there is much commonality in the guidelines being developed. The Joint FAO/WHO Expert Meeting on Pesticide Residues (JMPR) meeting 2000 proposed tests guidelines for studies with single oral doses for use in establishing acute RfD's for chemical residues in food and drinking-water (FAO/WHO, 2001a).

Cumulative effects

The Codex Committee on Pesticide Residues (CCPR) in 2001 "agreed that the development of cumulative risk assessment required further consideration, especially regarding the development of common understanding of methodology". Historically the evaluation of the safety of pesticides has been on the basis of single-chemical and single-exposure pathway scenarios. However an individual may be exposed by multiple pathways to multiple chemicals, some of which may have the same mechanism of toxicity.

The following is a brief description of potential issues to be covered throughout an assessment of potential cumulative risk for a group of pesticide chemicals that share a common mechanism of toxicity, based on US EPA's final guidance on cumulative risk assessment (US EPA, 2002):

- A common mechanism group (CMG) can be defined as chemicals shown to elicit the same toxic effect by essentially the same sequence of major biological events. For example organophosphorus pesticides affect the nervous system through cholinesterase interaction, and can be considered a CMG.

- For a CMG potential exposure pathways (i.e. food, drinking water, residential) and exposure routes (oral, inhalation, dermal) should be addressed for relevant pesticides, while an evaluation of common effects could be used to decide the common toxic end-point as well as the test methodology to be used in the assessment.

- A particular subset of chemicals belonging to the CMG can be chosen for the quantitative part of the assessment after an initial evaluation, but it would be critical for the overall evaluation that all CMG chemicals are accounted for in the assessment.

- On the basis of an appropriate dose-response method the relative potency of the chemicals can be estimated followed by an evaluation of the exposure scenarios resulting from the uses for each member of the CMG, and a final determination ofg the magnitude, frequency and duration for all pertinent exposure pathway/route combinations.

- As a final step the exposure data, exposure scenarios, and dose-response characteristics are combined to reach a coherent, realistic picture of the range of potential risks likely to be encountered by exposed populations and their associated probabilities.

Endocrine disrupters

An endocrine disrupting chemical (EDC) is a substance that alters function(s) of the endocrine (hormonal) system and consequently causes adverse health effects in an organism.

Research, primarily in animals, has shown that EDCs can act at multiple sites via different mechanisms of action, in most cases these mechanisms are not well understood. However two important issues are clear (WHO, 2002):

- Exposure to EDCs during the period when "programming" of the endocrine system is in progress may result in a permanent change of function of the system.

- Exposure during different life history stages may produce different effects, and notably exposure in adulthood may result in no detectable effect.

Analysis of human data, while generating concerns, has so far failed to provide firm evidence of direct causal associations between low-level exposure to EDCs and adverse health outcomes. Despite data shortage and other experimental difficulties, exposure to EDCs has been suggested to play a role in adverse human health outcomes, and concerns remain (WHO, 2002).

THE NEW RISK ANALYSIS FRAMEWORK

Whereas considerations related to human health risk have of course always guided safety assessment, it is also characteristic that a number of issues related to the management of food safety has often in the past focused primarily on the hazard in the food and therefore not extended to direct risk considerations. The focus on hygienic guidelines and later Hazard Analysis Critical Control Point (HACCP) systems in the microbiological area and the focus on maximum residues levels in the area of agricultural chemicals, such as pesticides and veterinary drugs, reflect an initial, and in many cases warranted focus on hazard. Evolution in a number of food safety areas through the nineties resulted in more focus on actual risk to human health, not only presence of hazard in the food. This was one of the reasons for the development of the Risk analysis concept in food safety.

Risk can be defined as 'a function of the probability of an adverse effect and the magnitude of that effect, consequential to a hazard(s) in food' (FAO/WHO, 1995).

Risk analysis comprises Risk assessment, Risk management and Risk communication (FAO/WHO, 1995). The Risk analysis process is typically initiated by governmental authorities, and although important parts of the process can be developed in international co-operative frameworks the full Risk analysis is at present primarily a national initiative.

The initiating part of Risk analysis is typically Risk management. The word management stems from the Italian verb 'maneggiare', meaning to ride a horse with skill, and in contrast to the confusion of the use and meaning of some of the other words of the Risk analysis realm, the perception of this concept is uniform and globally agreed. In Codex terminology Risk management is the process of weighing policy alternatives in the light of the results of risk assessment and, if required, selecting and implementing appropriate control options, including regulatory measures (FAO/WHO, 1996).

Risk Communication is the exchange of information and opinions concerning risk and risk-related factors among risk assessors, risk managers, consumers and other interested parties (FAO/WHO, 1999a).

Risk Assessment provides a scientific description of foodborne risks related to the occurrence of hazards in the food chain. Risk assessment is composed of hazard identification; hazard characterisation; exposure assessment; and risk characterisation.

While the development of risk analysis principles in relation to food safety stems back from Codex discussions as early as 1991, some other key developments have influenced this area. The new international trade agreements: World Trade Organisation (WTO) puts emphasis on scientifically based risk assessment and the WTO SPS agreement (Article 2, paragraph 2) establishes that sanitary measures should be based on scientific principles and should not be maintained without sufficient scientific evidence.

The FAO/WHO risk analysis framework and principles are in the process of being implemented in different national and international settings. The Joint FAO/WHO Food Standards Programme is the basis for the Codex Alimentarius Commission (Codex), and food safety standards, guidelines and recommendations established by Codex are generally recognised as the basis for harmonisation of sanitary measures. The aim of Risk Analysis is to

provide a means for a science based evaluation of risks associated with foods and the preventative measures which could be used to lower such risks. In this respect it is likely that decision systems modelled after the WHO/FAO Risk Analysis framework will be the tools of food safety managers in the future.

The new Risk analysis framework will enable all interested parties or stakeholders in food safety, including producers and consumers, to be more actively involved in the management and communication process. Therefore the assessment and management parts of risk analysis are sometimes presented as floating in a sea of risk communication, which thus provides the basis for interaction between all the players, including consumers, producers and other stakeholders (Figure 1).

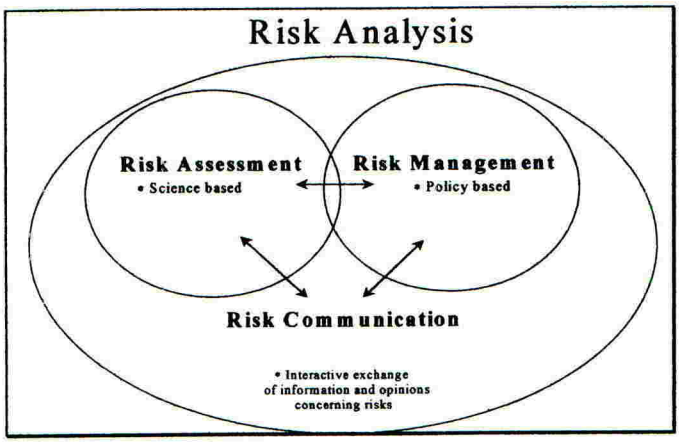

Figure 1. The WHO/FAO Risk analysis framework

While agricultural industries are facing global competition and major changes in the production systems, competition still has to be based on a cost-of-production basis. Such costs are now considered to be related to a number of issues in addition to the traditional narrow cost definitions. Additional issues include the environmental impact of agriculture, the role of products in human nutrition, food safety, food quality, animal welfare and market access.

Risk perception seems to converge a combination of scientific and cultural perspectives. Such sociological perspectives suggest that risks from technological developments have become important concerns in the social consciousness. A recognition is emerging of the need to include social dimensions of the debate over new technologies in the continued development of the risk analysis framework (Lomax, 2000).

Pesticides and Risk analysis

Since 1966 the Codex Alimentarius Commission has established Maximum Residue Limits (MRLs) for pesticides residues in food and animal feeding stuffs. For about 200 active ingredients MRLs have been established. These MRLs aim at the protection of the health of

the consumer and to relieve potential trade impediments. All those years Codex has closely worked together with the FAO/WHO Joint Meeting on Pesticide Residues (JMPR). JMPR evaluates toxicological and residue data and establishes Acceptable Daily Intakes (ADIs) and acute Reference Dose (RfDs). JMPR also recommends draft MRLs for consideration by Codex to be adopted as Codex standards.

In the nineties Codex has made significant progress in the implementation of risk analysis principles in the MRL setting process, both for chronic and acute dietary risks. In the same period, upon request of Codex, JMPR has remodelled its activities in a more regulatory way, in the sense that data required in national approval schemes had also to be submitted to the JMPR for review. Likewise, following initiatives taken at the national level to review already registered pesticides, Codex has successfully implemented a procedure to periodically review pesticides that are already in the Codex system.

One of the important areas of improvement has been in relation to exposure assessment. Until recently JMPR did not explicitly address exposure assessment of the chemicals they evaluated. In 1989 WHO Global Environmental Monitoring System (GEMS/Food) Programme was requested to prepare worst-case exposure assessments for the Codex Committee on Pesticide Residues. While these theoretical maximum daily intakes (TMDIs) were useful in providing a scientific and cost-effective method for assuring safety for about 90% of pesticides, concerns arose over several pesticides for which TMDI calculations could not confirm safe use.

In 1995, an FAO/WHO consultation held in York, UK proposed using the median residue instead of the regulatory maximum limit in assessing long-term chronic exposure. At the same consultation processing factors were identified as having the potential to significantly reduce concerns for residues in food as consumed, especially for cereals and grains. While almost all chronic exposure concerns have been resolved, there are a number of cases where such estimations show that the ADI is being approached and may, in the future, warrant further consideration of possible refinements in the exposure assessment. Additional information on consumption of processed foods would be useful to take advantage of processing data. In addition, the use of probabilistic methods has been suggested as a more realistic description of exposure rather than using deterministic or point estimates.

Some criticism has been voiced because the JMPR exposure assessment at international level often does not consider the aggregation of other relevant food sources, water, air and dermal exposures. It is important in this connection to realise that also for pesticides, the persons exposed occupationally may be at the highest risk. While aggregate exposure assessments are considered relevant at the national level, WHO in other connections routinely uses aggregate exposure assessments also internationally, e.g. in developing international recommendations for contaminants, including pesticides in the WHO Guidelines for Drinking-Water Quality. Aggregate exposure is particularly important for certain chemicals, which are present at significant levels in environmental compartments.

Risk assessment efforts and especially efforts to evaluate the importance of different sources of exposure to pesticides has recently led to new management efforts specifically aimed at sources (foods) most important for the human health risk. For example the United States prohibition of the use of methyl parathion in 36 crops (including 'risk-driving foods' such as peaches, apples, pears, green beans and grapes) in 1999 has effectively eliminated dietary risks while requiring only a modest reduction in the use of this economically important chemical

(Consumers Union, 2001). At the international level there are initiatives to reduce the risks of pesticide use such as the OECD's pesticides risk reduction programme and the FAO programme on integrated pest management (IPM).

STRATEGIES TO REDUCE RISK OF EXPOSURE TO PESTICIDES

While the problems discussed and reported in many developed countries relative to the health related effects of the use of pesticides in agriculture often focuses on residues in food, the major proportion of the full disease burden related to pesticide use in a global sense relates to the risk of poisoning through poor handling or disposal practices.

The realization of this issue has prompted stakeholders to suggest and pesticide industries to initiate actions in this area. Such action should include activities related to improved educational efforts for personal involved in the sales and distribution of pesticides at local level, efforts to train farmers and families in safe use and integrated pest management as well as efforts to manage the risks of waste management through life-cycle initiatives.

Efforts to train farmers and their families in the proper handling of crop protection products can be successful through building alliances between industry, governments, NGOs and international agencies. The activities should also promote compliance with international codes of conduct, such as the FAO Code of conduct on the distribution and use of pesticides, and promote national legislation that support the codes. Action in this area should try to link training for safe use to integrated pest management, and monitoring of the effects of such efforts is very important in the continuous improvement of the situation. Pilot projects in this area, such as a CropLife project initiated in Guatemala in 1992 with a continued roll-out to other Latin American countries has shown, also through independent audit, the potential for such strategies to succeed (Ruiz, 2002). And some of the experience gathered at such pilot projects has shown the importance of the creation of public/private partnerships and co-operation with NGOs. Interestingly such experience also suggest that housewives could represent the most influential sector for adoption of change, while children seem to be generally more receptive to adoption of improved practices.

In considering a broader approach towards risk reduction in the are of pesticide use, serious consideration should also be given towards the elimination of the most dangerous classes of pesticides. Likewise consideration needs to be given to the issues related to the management of obsolete stocks, also through new initiatives such as specific disposal projects.

ORGANIC PRODUCTION

There does not seem to be a simple, generally accepted definition of organic farming. It has been pointed out that often organic farming has been defined for what it is not; at the same time a simple definition, such as 'farming without chemicals' misses out several key characteristics of fundamental importance (Lampkin, 1990). Codex has prepared guidelines for organically produced foods, but does not suggest a specific definition of organic foods (FAO/WHO, 2001b). Nevertheless it is probably generally agreed that the organic label is not a health claim, it is a process claim (Kouba, 2002).

The data base for comparison between organic and other types of farming is very weak, but in general it could be stated that while organically produced foods has lower levels of veterinary drugs and pesticides, organic farming could lead to a higher risk for the contamination of products for parasites and micro-organisms present in animal manure (Kouba, 2002). Recent US data-sets showed that foods from organic farming had clearly reduced pesticide residues compared with products from conventional farming (Baker et al., 2002).

An important health related issue often discussed relative to organic products is the level of mycotoxins, of which aflatoxin is probably the most important, because of the potential of liver cancer induction at very low doses, if ingested over a prolonged period of time. The scientific database in this area is, as is often the case, not unambiguous.

This lecture does not intend a full discussion of the health related issues to be investigated in a comparison of chemically based and organic farming, but as a point in case will just briefly touch on data related to the issue of mycotoxins in milk. In a review of relevant studies described by Woese *et al.* (1997) a lower level of aflatoxin M1 in organic than in conventional milk is reported. Skaug (1999) found a lower level of ochratoxin A in Norwegian organically produced milk as compared to traditional milk. On the other hand Ghidini *et al.* (2002) in an investigation of Italian milk reports that while both organic and conventional milk are below the EU legal limit of 50 ng/litre, the concentration of Aflatoxin M1 was significantly higher in organic than in conventional milk. Interestingly, the same study found organochlorine pesticides residues in both some organic and some conventional milk samples. It is likely that good animal feeding practices in the organic production sector can go a long way to assure that the potential for use of mycotoxin-contaminated feed to dairy herds is kept at an acceptably low level.

Another important issue relative to organic farming is land usage. Avery (1997) elaborated on this issue, referring to data showing a decrease in grain-equivalent yields from what was characterized as "successful organic farming" of 21 per cent as compared to traditional farming with pesticide use (Hanson *et al.*, 1997). The simple arithmetics of this situation would suggest that moving to organic farming globally would result in a need for 21% more wild-land to be turned into arable land. The potential of decreased yields needs to be balanced against a potential increased sustainability; some comparative studies analysing biomass and N soil availability and leaching show that the organic system could improve agricultural sustainability and environmental quality while even maintaining similar crop yields (Poudel *et al.*, 2002).

While discussions of risk/benefit relative to the human health issues of pesticide use versus organic farming often centres around food contamination issues, such as the presence of pesticide residues and mycotoxins in food, it should be noted that the major health issues related to non-safe use of pesticides in many developing countries need also to be addressed.

While the present market share of organic food in European countries is quite low (0-4%), and probably lower in most other parts of the world, the market is increasing in some European countries and could increase even further in the future (Kristensen & Thamsborg, 2002). The market shares are very different from product to product with milk for consumption showing some of the highest market shares.

THE USE OF GENETICALLY MODIFIED PLANTS

Biotechnology is likely to have enormous potential to address a broad range of food-related problems, from food security and nutrition to food safety, and many of these issues are directly related to crop-protection strategies. On the other hand, biotechnology has created a large public concern with regard to its potential effects on human health and the environment, as well as on the right of consumers to choose what they eat.

The genetically modified (GM) crops which are presently on the international market mainly aim towards an increased level of crop protection by introducing resistance against insects, viruses or herbicides.

The **insect resistant** GM-crops currently are modified in such a way that they produce the toxin of the bacterium *Bacillus thuringensis* (*Bt*) which has been confirmed safe for human beings but toxic to certain insects. Crops that permanently produce *Bt* toxin have been shown to require less use of additional insecticides in specific situations, such as in areas with a high level of pest pressure. In some situations potential environmental risks, such as the detrimental effect on beneficial insects or a faster induction of resistant insects have been identified and monitoring strategies for the control of these risks are under development.

Virus resistance is typically achieved through incorporation of a gene coding for a virus protein, conveying to the crop resistance to the specific virus. For some constructs the probability that the viral constructs used in the crops could interact with wild type viruses and result in new plant pathogens is a potential risk that needs further investigation. Improved mechanisms for virus resistance such as the enhancement of natural resistance mechanisms are under development.

Herbicide tolerant crops enable a more targeted approach to weed control. Under certain agro-ecological situations such as a high weed pressure the use of herbicide tolerant crops has resulted in a reduction in quantity of the herbicides used. Also the need for tilling can be reduced in critical soil conditions. In other local situations the potential detrimental consequences for plant bio-diversity, wild life and a decreased use of the important practice of crop rotation could represent potential drawbacks and need further investigation. In some situations out-crossing of the herbicide resistance genes has been reported and could need further monitoring.

These current applications of genetic modification in the agricultural sector are thus said to have resulted in benefits in some areas, however, these benefits are often perceived by consumers (especially in Europe) to be mainly related to the production sector and not directly related to the consumer. In the future, however, non-allergenic peanuts, corn with increased essential fatty acid content, rice with vitamin A or traditional crops with improved draught resistance may offer significant advantages over their non-modified counterparts. Some of these potential benefits could be especially directed towards developing countries. Therefore the somewhat negative attitude towards GM foods which seem to prevail in some regions could result in problems for future potential 'public good' developments. Let us therefore briefly try to discuss the developments which have led to this negative attitude.

Issues of concern

Since the first introduction of a major GM food (herbicide resistant) on the market in the mid nineties, increasingly there has been concern amongst politicians, activists and consumers, in particular in Europe, about this type of food. In general, consumer confidence in the safety of their food supply has decreased due to a number of food scares that took place in the second half of the nineties. This has also had an impact on the discussion about the acceptability of GM food. Consumers questioned the validity of risk assessments performed both on consumer health and environmental risks, focusing in particular on problems related to the prediction of long term effects.

Other topics in the discussion were allergenicity and antimicrobial resistance. The concerns of consumers triggered amongst other issues a discussion on the necessity to label GM food, allowing consumers to make an informed choice. At the same time this demand revealed shortcomings in the analytical methodology to detect traces of GM food. In response to these concerns the European Community has refined its GM regulations and new legislation is under consideration. In particular it focuses on risk assessment and introduces far reaching labeling provisions and traceability at all stages of the food chain.

Comparing different regions of the world, people have specific and often different attitudes to food. Food is a part of the historical identity, the societal life, and in some instances may have religious nuances. Technological modification of foods and food production methodology can result in consumer resistance in some regions, especially in the absence of good communication of preventive risk assessment efforts and benefit evaluations.

Intellectual property rights, especially patenting obligations of the WTO/TRIPS agreement (agreement for trade related aspects of intellectual property rights), have been discussed for their consequences on the further availability of crop diversity such as land races. A WHO publication on Genomics and World Health discusses the problems of assuring equal access to genetic resources and sharing of benefits, an issue also addressed in the Convention on Biodiversity. This WHO publication also discusses potential problems of monopolisation, doubts about new patent regulations in the field of genetic sequences and asks for an international rethinking and harmonization. These considerations are not only relevant when evaluating the potential of genomics for health care but should also be considered in relation to GM foods.

Concerns about growing influence of the chemical industry in the seed markets has also been voiced. Certain groups are concerned about what they see as an undesirable level of control of seed markets by a few chemical companies. Sustainable agriculture (and biodiversity) benefits most form the use of a rich variety of crops planted. This both in terms of good crop protection practices as well as from the perspective of society at large and the values added to food. These groups fear that as a result of the interest of chemical industry in seed markets the range of varieties used by farmers is reduced mainly to GM crops impacting upon the food basket of a society as well as in the long run on crop protection (development of resistance against insect pests and certain herbicides). Exclusive use of herbicide tolerant GM crops will also make the farmer dependent of these chemicals. These groups fear a dominant position of chemical industry on agricultural development in a direction that they don't see as sustainable.

Perception and communication within a risk analysis framework

Sadly, the realization that both proponents and opponents of GM foods might have some valid points, have only reached the international discussions lately. A number of previous statements from regulators, producers and scientists involved in the area of biotechnology seem to suggest that they feel the problems really originate in the consumers incapacity to understand and scientifically compare the risk of biotechnology foods to the risk of traditional food. The process of a scientific assessment and the following management decisions was considered by many regulators to be too complicated for the common consumer. To base future deliberations upon this view could be a very serious second mistake in risk communication relative to biotechnology. The first mistake has been not to involve consumers – and other interested parties – in the risk analysis process from the on-set.

Generally, pursuing a strategy of comparing the risk of biotechnology food with traditional food is inherently problematic. The question of new or additional risks of an involuntary nature cannot be adequately addressed only through a reference to existing, and in many cases already accepted risks of traditional food. This is by no way a suggestion not to inform about the very clear difference in risk (often to the advantage of GM food) when compared to a number of traditional food items carrying natural toxins or chemical or microbiological contamination. Aflatoxin is present at certain levels in a number of foods and do no doubt cause a number of cancer cases every year, whereas micro-organisms in food every year result in millions of deaths globally. We should, however, not think that this will make the basic questions related to GM foods go away. The potential for a risk will always have to be explained, as will the assessment systems we put in place to lower this risk. And improvements will always be expected, both in lowering existing risks and in the way we prevent new risks from arising.

In realising the increased need for risk communication, the only goal for the regulators should not be to gain the trust of the consumers. The main problem is to adequately address all relevant potential effects of GM food, and in doing so acknowledge the input from all interested parties participating in the overall risk analysis process. By effectively performing this process, the evaluation system will earn the trust of the consumers.

Improving assessment and evaluation systems globally

Relative to the evaluation of GM foods, one important cause for concern is the fact that a detailed evaluation and testing approach for GM foods has not been agreed upon in the international community. The Codex Alimentarius Commission is developing principles for the risk analysis of foods derived from modern biotechnology (GM foods).

The premise of these principles dictates a pre-market assessment, performed on a case-by-case basis including an evaluation of both direct effects (from the inserted gene) as well as unintended effects (that may arise as a consequence of insertion of the new gene). The principles are at a very advanced stage of development and are expected to be adopted in July 2003 (FAO/WHO, 2002). Codex principles do not have a binding effect relative to national legislation, but are referred to specifically in the SPS/WTO agreement, and can be used as a reference in case of trade disputes. The fast development of these principles (effectively work only started in 2000) reflects a realization of all Member States of Codex (168 at the moment) that international co-operation is really the way forward also in this important area.

Risk assessment experience in one country should be shared with other countries, and the efficiency of such sharing will gain significantly from the international principles for risk analysis. It is essential that governments and international NGOs find solutions by interacting, sharing and understanding each other's views and perceptions. In doing this there is a clear need, especially in developing countries, to strengthen the capacity in risk assessment, risk management and also risk communication.

Biotechnology could have an important role to play to improve nutrition and food security world wide. But unless we acknowledge the right of consumers to have concerns, to be informed, and to be heard of their opinion, and unless we accept the need for increased research on possible effects on human health of GM foods, we will not achieve the progress we hope for. In addition it will be an important signal for the future whether the direction of public research as well as industry research in this area will reflect the need for a more concerted effort in the area of future 'public good' use of this technology.

Work is presently under way in WHO to present a broader view of GM food evaluation enabling the consideration of important factors other than human health and environment. This more holistic evaluation of GM organisms and GM products would also consider food security, social and ethical aspects, access and capacity building. The report will be finalized early in 2003.

Potential risks of GM foods derived from GM organisms need to be assessed on a case by case basis, using scientifically accepted and harmonized concepts, where also regional specificities are taken into account. GM foods presently available on international markets are not likely to present human health risks.

THE FUTURE OF MANAGING FOOD SAFETY RISKS

The new risk-based approaches will make their way into all parts of the global market, including the developing countries, which are likely to become more and more important agricultural producers. The introduction of a risk-based framework will enable developing countries to learn from mistakes (and successes) elsewhere. These countries have the potential to "leap forward" into preventative systems focusing on risks. The benefits of improving food safety amount to a win-win situation with improved national health as well as improved export potential. Sustainable development of agriculture at the global level will be in the interest of everybody, and relates both to improvements in production efficiency and product safety.

The continued effort to lower foodborne risk will lead to a number of situations where new developments in food production techniques or food control potential will result in not only more efficient food production, but also safer foods. And why should this not be? The history of food production is full of safety improvements, and hopefully this trend will continue and be strengthened in the future. New technologies, including biotechnology, should be used also for safety and nutrition improvement purposes, and the scientific basis for such developments should be clearly communicated between all interested parties.

In the area of crop protection chemicals a number of developments will hopefully contribute to safety improvements also in the future. A more holistic approach to the evaluation of problems related to pesticide use is now focusing more on the risk of poisoning through poor handling

or disposal practices. New methodology for exposure assessment to chronic hazards, as well as assessment of risk related to a combination of hazards are areas under development, and hopefully regulatory agencies, the industry and other stakeholders will in the future be able to handle these issues in an open risk-based framework, dominated by efficient (two-way) risk communication.

A key area of the developing risk analysis paradigm is the increased interaction between stakeholders and authorities, one of the important aspects of risk communication. Interestingly the realization of the need for communication has not only been developed through international and national initiatives towards defining a better, more transparent and inclusive system for the assessment and management of foodborne risks.

A corresponding development has taken place between some of the stakeholders/key-players in the public debate related to these risks. The industry as well as some of the traditional critical non-governmental organizations are increasingly realizing that a real debate needs to relate to the real issues, hopefully avoiding both exaggerated claims and unnecessary avoidance of debate. It is therefore encouraging to see that a healthy (sic!) debate of real issues is now mounting also in the pesticides area.

DEVELOPING COUNTRIES PROBLEMS

The increases in data requirements and the periodic review of existing pesticides in the Codex system has had the unexpected result of phase-out of Codex Maximum Residues Levels (MRLs) for a number of old pesticides. Such MRLs are typically set after an evaluation of data supplied by the manufacturer. It turned out that manufacturers in many cases were no longer willing to sponsor old chemicals in the framework of national and regional review programmes due to increased data requirement and the need to meet updated criteria to protect the health of man and environment. This is in particular the case for pesticides for which patents have expired. As a consequence data owners were also no longer able to meet the data requirements of the JMPR. In response Codex has withdrawn many Codex MRLs of these old pesticides.

These developments are not necessarily favourable for developing countries. Many developing countries are important producers of fruit and vegetables and face problems in exporting their products in the absence of Codex standards for their products. On a global scale these commodities are considered as minor crops in which manufacturers have no interest at all, leaving it to others to generate the necessary residue trial data. Usually developing countries have problems in generating sufficient data to establish international standards for commodities relevant to them. Where developed countries are able to replace old chemicals by newer ones, often claimed to be safer, developing countries can't effort this as new pesticides are usually more expensive than old ones. So they have to rely on these old products for which importing countries increasingly set MRLs at the limit of detection.

As Codex is invited to give due regard to the needs of developing countries avenues have to be explored to alleviate the consequences of increased data requirement for the agricultural production in these countries. Developing countries should be encouraged to establish a regulatory infrastructure forcing manufacturers to generate and submit data before their products can be marketed in these countries. Developing countries should consider regional

co-operation to combine resources and generate data for crops of prime importance to their region. Finally Codex should revisit its current MRL setting procedures and promote in particular ways to establish MRLs by extrapolating form one crop to a related crop.

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